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Overview on the use of enchytraeids in Terrestrial Model Ecosystems (or »microcosm«) investigations

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Abstract

The use of terrestrial microcosms or terrestrial model ecosystems (TMEs) as a tool in ecological and ecotoxicological investigations is currently increasing. In this contribution an overview is given on studies investigating specifically the role of Enchytraeidae in various types of intact soil core TMEs and gnotobiotic microcosms. Most studies focus on the interaction between enchytraeids and other structures and functions of the ecosystem like microbial activity, litter decomposition and mineralization. In some of these studies an »anthropogenic stress« was induced (e.g. heavy metal or acidification).

The latest approach in this area is the use of the abundance and diversity of enchytraeids as effect end–points in studies using TMEs as an ecotoxicological test system. The TME–system is planned to be used in the registration or notification process for pesticides or environmental chemicals. Currently its suitability is investigated in a ring test-like TME study performed in parallel at four European locations: Amsterdam (The Netherlands), Bangor (Wales, U.K.), Coimbra (Portugal) and Flörsheim (Germany). First results indicate that the abundance and diversity of enchytraeids are suitable effect end-points to detect the impact of chemicals on ecosystems.

Introduction

Most of the data concerning terrestrial ecosystems and effects of chemical stressors to the soil biocoenosis are derived from laboratory investigations, which are not representative for ecosystems. However, field tests which can represent ecosystems are difficult to reproduce, costly and time-consuming. An alternative approach is the use of microcosms or model ecosystems (GILLETT 1989). Therefore, the use of terrestrial microcosms as a tool in ecology and ecotoxicology has increased recently. Since the term ›microcosm‹ is only weakly defined, the term ›Terrestrial Model Ecosystem‹ (TME) will be applied in this contribution.

Following a definition coined by MORGAN and KNACKER (1994) a Terrestrial Model Ecosystem is a controlled, reproducible system that attempts to simulate the processes and interactions of components in a portion of the terrestrial environment.

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Table 1: Terrestrial Model Ecosystem studies and a brief description of used methods

Author / Year	*Soil*	*Size*	*Enchytraeidae*
RÖMBKE 1989 RÖMBKE et al. 1994	Intact soil cores including undisturbed layering	Depth = 60 cm, diameter = 18 cm	Natural microbial and meso-fauna community and natural vegetation
VAN VLIET et al. 1993 VAN VLIET et al. 1995	Mixed, air-dried soil from the surface horizon	65 g, 18 x 27 cm	*E. minutus* inserted
BAUER et al. 1994	Frozen soil monoliths from the surface area	Depth = 15 cm, 25 x 25 cm	Re-immigration experiments
FÖRSTER et al. 1995	Sieved, homogenised soil from the top soil	80 g, glass tubes with a length of 25 cm and a diameter of 4 cm	*F. ratzeli* inserted
REICHERT 1996	Disturbed, arable soil	Depth = 57cm, diameter = 60 cm	Natural population
JAFFEE et al. 1997	Sieved, heated and aired soil	26 g in 25 ml vials	*E. crypticus* inserted
STOCKINGER et al. 1997	Frozen soil	10 x 7 x 5 cm	*E. buchholzi* inserted

Enchytraeids as characteristical soil living animals with high numbers and a high biomass play an important part in the functioning of many terrestrial ecosystems (DIDDEN 1993). To minimize the still existing lack of knowledge concerning the role of enchytraeids in soil ecosystems and to support the understanding of the soil processes in total, enchytraeids should act as a main focus point for further TME investigations. Additionally, the use of enchytraeids in TMEs as an ecotoxicological test system can provide more relevant data on effects of chemicals in the terrestrial environment.

Overview on results of ecolgical and ecotoxicological studies

The role of Enchytraeidae in terrestrial ecosystems and their reactions to chemical stressors have been investigated in many different types of Terrestrial Model Ecosystems (Table 1).

In most of these TME studies a relatively small amount of more or less disturbed soil was used and only one species of Enchytraeidae was inserted. These approaches are very useful to investigate single endpoints. On the other hand, undisturbed (intact) soil cores (Fig. 1) are more suitable to simulate field situations. This method allows to investigate effects of stressors on the Enchytraeidae under realistic conditions and to extrapolate the results to the field site.

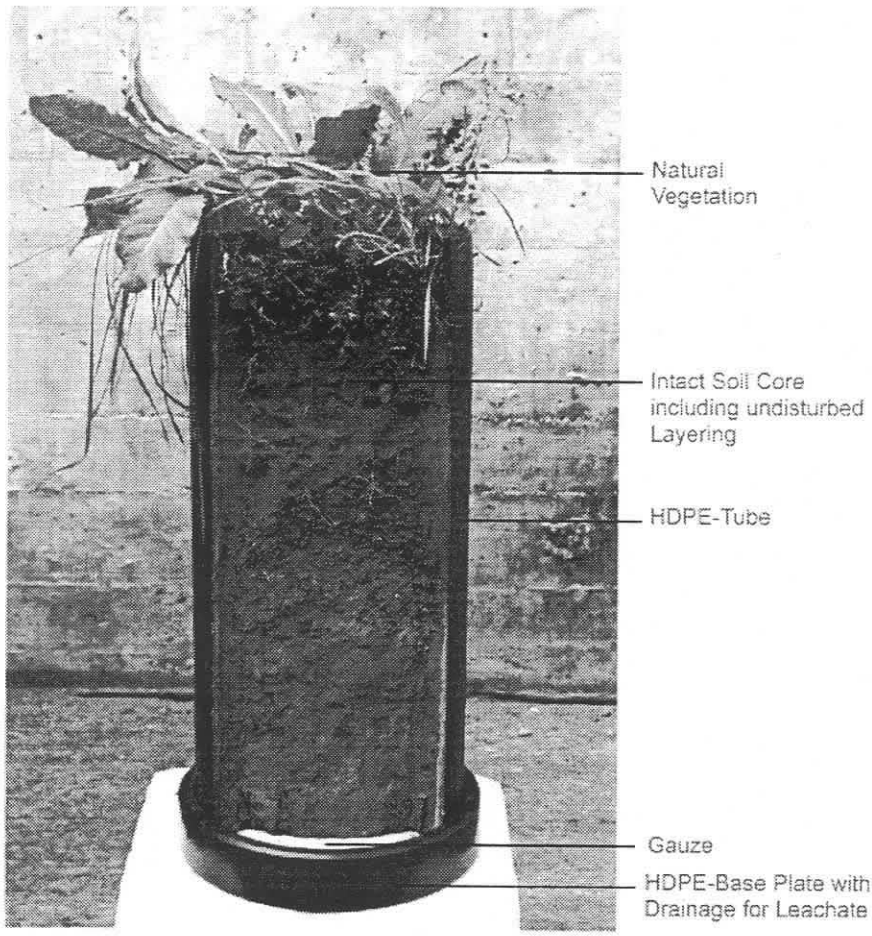

Figure 1: Longitudinal section of an intact Terrestrial Model Ecosystem including natural vegetation and undisturbed layering

VAN VLIET and co-workers have shown in small TMEs that the burrowing activities of enchytraeids caused an increase in soil porosity (VAN VLIET et al. 1993) and a shift to more elongate pores (VAN VLIET et al. 1995). FÖRSTER et al. (1995) could prove that the presence of enchytraeids in TMEs leads to an increased microbial respiration. They stated that feeding activities of enchytraeids probably enhanced a better mobilisation and bioavailability of nitrogen and therefore promote microbial growth. A study of the relation between enchytraeids and nematophagous fungi in TMEs (JAFFEE et al. 1997) showed that the number of worms increased if pelletized hyphae of these fungi were added. Due to this the number of plant parasitic nematodes increased also and the conclusion was drawn that enchytraeids interfered with biological control by ingesting and consuming fungi. STOCKINGER et al. (1997) could prove that reduced microbial biomass in soils leads to a reduction in the number of microphytophagous enchytraeids.

Beside these ecological investigations there are also a few ecotoxicological TME studies which investigate effects of environmental stressors (e.g. heavy metals, pesticides)

on Enchytraeidae. Possible endpoints to measure effects can be diversity, abundance, biomass, vertical distribution and population dynamics (e.g. juvenile/adult ratio).

RÖMBKE (1989) investigated effects of two chemicals on the enchytraeid population of intact TMEs. He found that the assemblage of species and their abundance as well as the vertical distribution in the untreated soil cores did not differ from the field site where the TMEs had been extracted 4 month before. The biomass was slightly higher in the TMEs. These results were supported by two other studies (RÖMBKE et al. 1994, REICHERT 1996). Additionally the ratio of juvenile to adult worms was not modified (RÖMBKE et al. 1994). In the same study RÖMBKE and co-workers further observed that a treatment with the insecticide E 605 at a high concentration caused a reduction in the number and biomass of the enchytraeids in the soil cores and also in the field. In the above mentioned study (RÖMBKE 1989) the vertical distribution of the enchytraeids in the TMEs changed after application of Na-Pentachlorphenol in high doses.

Preliminary results of a EU-Project

In a current EU-Project the suitability of TMEs for the usage in registration or notification processes for pesticides and environmental chemicals respectively is investigated in parallel in four European laboratories (Amsterdam (The Netherlands), Bangor (Wales, U.K.), Coimbra (Portugal), Flörsheim (Germany)).

This project is based on recommendations from a draft guidance paper on the use of TME's for the ecotoxicological assessment of chemicals in soil (KNACKER and

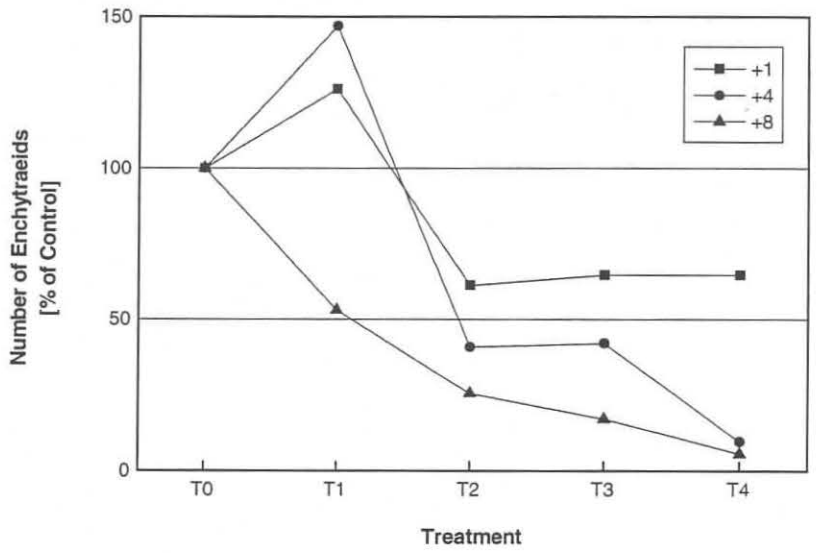

Fig. 2: Average number of enchytraeids (% of control) in differently treated TMEs. (T0 = control, T1 = lowest concentration, T4 = highest concentration). +1 = first sampling one week after application, +4 = second sampling four weeks after application, +8 = third sampling eight weeks after application.

MORGAN 1994). In this paper the use of enchytraeids as a routine endpoint in such studies was proposed for the first time.

Preliminary results show that there is no difference concerning diversity, dominance spectrum and abundance of enchytraeids between the untreated, intact soil cores and the field site after a period of two months. In the TMEs which were treated with a fungicide, however, there is a clear tendency that the number of worms is reduced in the soil cores contaminated with high concentrations (Fig. 2). In addition, also the number of species decreased. These observed effects increased during the exposure period (Fig. 2).

Conclusion and outlook

The data from the described investigations have shown that the results derived from TME studies are comparable to those from the field. The ability to mimic effects of e.g. pesticides observed under field conditions was much better when using intact TMEs compared to the results obtained from laboratory test systems (RÖMBKE et al. 1994).

The Enchytraeidae are a suitable organism group for ecotoxicological TME investigations. They are of utmost ecological importance (DIDDEN 1993) and excellent indicators for soil condition and environmental stressors (WESTHEIDE et al. 1991, RÖMBKE & FEDERSCHMIDT 1995). An additional reason for the use of enchytraeids is that they occur in nearly all soils (whereas earthworms avoid e.g. acid soils) and that they react at least as sensitively to agrochemicals as earthworms do. For a characterization of ecotoxicological effects on enchytraeids in TMEs, number and biomass of the worms, their vertical distribution and the ratio of juvenile to adult individuals seem to be the most sensitive parameters (RÖMBKE 1998, RÖMBKE et al. 1994).

Considering the ecological and ecotoxicological importance of enchytraeids in soils it is surprising that they are not used routinely in terrestrial microcosm studies. Probably the main reason why people hesitate to use them are some difficulties concerning their taxonomy. The latest key of European species is 40 years old (NIELSEN & CHRISTENSEN 1959) and many genera are in a need of revision. However, as indicated by DÜKER et al. (1999) higher categories like genera might be also useful for the identification of anthropogenic stress.

From all this the conclusion can be drawn, that an enhanced use of enchytraeids in undisturbed Terrestrial Model Ecosystems is highly recommendable for the assessment of the environmental risks of chemicals. To investigate special questions (e.g. single ecological relations) it might be also useful to introduce defined species in gnotobiotic TMEs.

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